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Exploring Land Use and Transport Interaction through Structural Equation Modelling

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Abstract

Transport systems and land use are two mutually interconnected elements: the location of the activities and their need for interactions produce transport demand; on the other hand, transport supply system supporting transport demand and performance levels of transport services affect the activity locations.
In this paper the relationship among the factors affecting transportation and land-use systems interactions was investigated and a GIS was used for exploring the relationship among some spatial variables regarding geographical features, activity location, demographic and economic characteristics, and transportation variables such as trip production and attraction, and accessibility. Analysing the relationship among the variables, unobserved or "latent" variables affecting land-use and transport interactions were identified and introduced in a structural equation model. This approach allows the modelling of a phenomenon by considering both unobserved "latent" constructs and observed indicators describing the phenomenon. The results show that travel behaviour is more influenced by the economic characteristics of population. These analyses allow identifying the relationships among variables related to land use and transportation system, and can provide some findings for transportation planners as well as assisting the complex process of urban planning decision-making.

Keywords: Land use and transport interactions; Structural Equation Modelling.

1. Introduction

The configuration of urban areas can be conceived as the result of interactions between the transport and the planning system (land use), which are mutually interconnected. The term "land use" is related to the variety of human activities which are held in the urban space. Land use and transportation interaction is a dynamic process

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that involves changes over spatial and temporal dimensions between the two systems. Changes in land use system can modify the travel demand patterns and induce changes in transportation systems. Transportation system evolution, on the other hand, creates new accessibility levels that encourage changes in land use patterns (Shaw and Xin, 2003). This kind of relationship is sometimes referred to as the "land use transport feedback cycle", emphasizing a feedback relationship which can be summarized as follows. The distribution of land uses, such as residential, industrial or commercial, over the urban area determines locations of human activities such as living, working, shopping, education or leisure. The distribution of human activities in space requires spatial interactions (trips) in the transport system to overcome the distance between the locations of activities. The distribution of infrastructure in the transport system creates opportunities for spatial interactions and can be measured as accessibility. The distribution of accessibility in space determines location decisions and so results in changes of land use system (Wegener and Furth, 1999). Accessibility can be measured as a function of variables which appear attractiveness of the target area (for example, the number of jobs the reason for travel between home and work) and cost variables related to the transportation system (such as travel time or travel distance to move from the origin area to the destination). When an area has an intervention improvement in the transport system, also improves accessibility for which the area becomes more attractive as a destination of the move or as industrial or residential area in relation to the type of intervention performed. The relationship between land use and transportation system in an urban area can be described through some spatial variables regarding geographical features and activity location, demographic and economic characteristics, transportation variables, and characteristics of the mobility demand. Some research studies were conducted for analysing the relationship among these variables by using Geographic Information System (GIS).

In this paper the relationship among the factors affecting transportation and land-use systems interactions was investigated, and a GIS was used for exploring the relationship among some variables regarding geographical data, activity location, demographic and economic characteristics, and transportation variables such as trip production and attraction, and accessibility. By analysing the relationship among the variables, unobserved or "latent" variables affecting land-use and transport interactions were identified through a Structural Equation Modelling (SEM). This approach allows the modelling of a phenomenon by considering both unobserved "latent" constructs and observed indicators that describe the phenomenon. This research aims to explain the relative influence of spatial variables of land use, accessibility, socio-demographic and economic characteristics on travel behaviour. The paper is organized as follows. In the next section a brief review of studies regarding transport and land-use interaction adopting SEM is presented. In section 3 the case study is described. Section 4 presents the methodological framework of SEM and the analysis performed. Finally, concluding remarks are contained in section 5.

2. Literature review

Although SEM has been applied in travel behaviour research since the 1980s, as reported by Golob (2003), applications involving travel behaviour from the perspective of land use remain scarce. As an example, Bagley and Mokhtarian (2002) examine the relationship of residential neighbourhood type to travel behaviour, incorporating attitudinal, lifestyle, and demographic variables, by using data collected from residents of five neighbourhoods in the San Francisco Bay Area in 1993. They found that attitudinal and lifestyle variables had the greatest impact on travel demand among all the explanatory variables. When attitudinal and lifestyle variables are introduced, the land use variables cease to have an important role in explaining mobility patterns. By contrast, residential location type has little impact on travel behaviour. This is perhaps the strongest evidence to date supporting the speculation that the association commonly observed between land use configuration and travel patterns is not one of direct causality, but primarily due to correlations of each of those variables with others. In particular, the results suggest that when attitudinal, lifestyle, and socio-demographic variables are accounted for, neighbourhood type has little influence on travel behaviour.

Simma and Axhausen (2003) explore the impacts of personal characteristics and spatial structure on travel behaviour, described among other things by accessibility measures. The models are focused on the 1992 Upper Austrian travel survey and transport model. The results highlight the key roles of car ownership, gender and work status in explaining the observed level and intensity of travel. The most important spatial variable is the number of facilities, which can be reached by a household. The accessibility measures have rather little explanatory power. Although the findings in this study indicate that the spatial structure is not a decisive determinant of traffic, the results provide useful hints for possible policy alternatives.

Abreu e Silva et al. (2006) examine the relationship between land use and socioeconomic characteristics, residential location and travel behaviour. The model proposed is based on data regarding the Lisbon Metropolitan Area. In the model, travel behaviour choices are multi-dimensional including total time away from home, number of trips and trip distances by three types of modes, car ownership, and possession of a transit pass. Land use is captured in terms of GIS-based measures of land use and transport supply variables centred on both home and work locations. The analysis provides strong evidence in favour of using land use and urban form designs and planning both around residential neighbourhoods and workplace areas. The overall model shows that land use patterns affect travel behaviour in a significant way. This effect is different for residence and workplace locations, and sometimes not even direct. A great part of the influence of land use on travel behaviour is mediated by the commuting distance that tends to be shorter for the residents of more traditionally urbanized zones. The commuting distance affects directly both the number of cars in the household and pass ownership. On the other hand, land use variables are influenced by the socioeconomic and demographic characteristics of individuals and households. Moreover, some more commonly accepted travel behaviour variables also influence land use variables, as car ownership. If we consider the travel behaviour variables as the visible outcomes of lifestyle preferences, these results are partially in accordance with the results obtained by Bagley and Mokhtarian (2002). Results provide quantitative evidence of the extent to which workers living in denser, central, compact and mixed zones make more intense use of transit and non-motorized modes, and tend to have lower car ownership levels. Workers in areas well served by freeways tend to make more intense use of their cars, although this does not inhibit using transit. Similar results were obtained by similar models proposed by the same authors in Abreu e Silva (2006) and Goulias (2007; 2009).

Van Acker et al. (2007) construct a SEM based on Flemish Regional Travel Survey data (2001-2002). A two-step approach was undertaken to measure the relative influence of land use and socio-economic characteristics on travel behaviour. Travel behaviour was mainly influenced by the respondent's social status: a high social status was associated with a more complex travel behaviour. Travel behaviour was affected, especially indirectly, by the individual's role within the household. The effect of land use was limited. Furthermore, indirect effects remain important to understand the complexity of travel behaviour. Tschopp and Axhausen (2007) focus on the impact of transport infrastructure on the population change of municipalities and regions. First results indicate that the influence of accessibility on spatial development differs considerably over time and space.

This literature review shows that the application of SEM methodology to the analysis of land use-transport interactions provides important information regarding the relationships between the observed and latent variables.

3. Case study

3.1. Demographic and economic characteristics

The case study focuses on the urban area of Cosenza, which forms a single urban area together with Rende in the northerly direction. This urban area, placed in Calabria Region (South of Italy), is the most important centre of attraction for all the towns of the province because it performs some administrative functions and offers different services and job opportunities. Furthermore, Rende is home to the University of Calabria (UniCal), which affected mobility characteristics of all the urban centres of the province. Over 33,000 students and about 2,800 members of staff attend the campus.

For providing a preliminary characterization of the urban area, it is necessary to report some information about population and economic activities (ISTAT, 2001a).

Concerning population and housing (table 1), more than 70,000 people are resident in the city of Cosenza; on the other hand, the city of Rende has a resident population of about half of Cosenza population. It is necessary to specify that Cosenza and Rende feel the effects of the presence of the University of Calabria; so, in addition to the resident people there are other many people (university students) living in the urban area, and especially in the city of Rende. The population of the urban area is equally spread between males (48%) and females (52%). About 68% of the urban area population belongs to an intermediate class of age (between 15 and 65 years old), which represents the class of persons of working age; about 18% of people are older than 65 years and about 14% younger than 15 years.

Table 1. Population and housing data

	Cosenza	Rende	Urban area
Total population (inh.)	72,998	34,421	107,419
Male population (inh.)	34,689	16,948	51,637
Female population (inh.)	38,309	17,473	55,782
Population younger than 15 years (inh.)	9,432	5,351	14,783
Population between 15 and 65 years (inh.)	48,387	24,989	73,376
Population older than 65 years (inh.)	15,179	4,081	19,260
Families (nr.)	27,476	12,090	39,566
Families with 1 member (nr.)	7,561	2,636	10,197
Families with 2 members (nr.)	6,635	2,560	9,195
Families with 3 members (nr.)	5,186	2,502	7,688
Families with 4 members (nr.)	5,516	3,185	8,701
Families with 5 members (nr.)	1,984	971	2,955
Families with 6 or more members (nr.)	594	236	830
Surface area (kmq)	36.82	44.72	81.54
Total housing (nr.)	31,129	15,727	46,856
Empty housing (nr.)	3,224	1,706	4,930
Building (nr.)	6,432	5,303	11,735
Population density (inh./kmq)	1,982	770	1,317
Housing density (nr. hous./kmq)	845	352	575

In the urban area there are about 40,000 families. A large part (about 26%) has one member; about 23% of families have two members; more than 40% are families with three or four components; finally, only 10% of families have five or more members.

The urban area fills up a surface area of about 82 kmq, and about 55% of the surface area is filled up by the city of Rende. By comparing population and surface area values of the two cities, Rende is larger than Cosenza, but it is less populated. This fact can be confirmed by observing the values of population density, which is the ratio of the population of a territory to the total size of the territory. The urban area offers about 47,000 housings, of which about 66% are in the city of Cosenza. By comparing the number of housings and surface area values of the two cities, Rende offers less housing than Cosenza.

Urban area labour force amounts to about 42,000 persons, of which about 66% of the city of Cosenza, and the remaining 34% of the city of Rende. In the urban area there are about 33,000 resident employed persons, and specifically about 22,000 in Cosenza (65%). Obviously, these percentages are correlated to the population size. In fact, in order to compare the employment data of the two analysed cities and to give more specific information about the levels of employment, some rates can be calculated. As an example, the regional employment rate gives an idea about the levels of employment by considering employed persons as a percentage of the population. In this study case, the employment rate is equal to 31% for the urban area, 29% for the city of Cosenza, and 34% for Rende; therefore, Rende has a major number of people employed compared to the total population than Cosenza. Analogously, the regional unemployment rate can be calculated, by considering unemployed persons as a percentage of the economically active population (labour force). The urban area presents an unemployment rate of about 21%, Cosenza of about 23%, while Rende has the lowest value, equal to 18%. By analysing the data about the employment by sector of the studied area, persons employed in the services represent 84% of the total employed persons, about 14% of resident persons work in the industry, and only 2% in the agriculture. Finally, 76% of employed persons are employees. In the urban area there are predominantly enterprises operating in the service sector (72% in Cosenza and 28% in Rende). The enterprises are generally small, with a staff of 4.4 employed in average. While in Cosenza most of people are employed in the sector of the public services, the enterprises located in Rende prevalently refer to the business activities (ISTAT, 2001b).

Concerning mobility and transport facilities, the analysed area represents one of the main junctions of the Calabria railways and road system. The A3 Salerno-Reggio Calabria motorway, the SS107 Paola-Crotone state road, and the n.19 and n.19bis state road cross the urban area. Furthermore, the urban area is crossed by the Sibari-Cosenza and Paola-Cosenza railways lines, which assure the rail link between the Tyrrhenian and Ionian rail director. Finally, in the urban area of Cosenza merged the regional railway lines to Catanzaro and Sila, which have a narrow gauge, and are managed by “Ferrovie della Calabria”.

3.2. Daily trips characteristics

Census data of the population (ISTAT, 2001a) also provide the data referred to the daily trips made by people from home to work and study places (commuter trips). The trips are distinguished into trips with destination in the place of residence (internal trips), and trips with destination outside the place of residence (external trips). However, it is necessary to observe that among the trips from Cosenza some trips have destination in Rende and *vice versa*. Therefore, these trips are internal trips for the urban area. In order to quantify these, some information collected by previous surveys are taken into account, and specifically a survey realized on the occasion of the urban traffic plan drafting of Cosenza (Festa, 2002). From the survey data, 54.6% of the trips per day made (for all purposes) by persons resident in the city with destination in other places had their destination in Rende. This percentage can be used for estimating the number of commuter trips with origin in Cosenza and destination in the urban area. Analogously, from the survey realized in the occasion of the urban traffic plan drafting of Rende (Festa and Stellato, 1997), a percentage of 72.3% of the trips per day made (for all purposes) by persons resident in Rende with destination in other places had their destination in Cosenza.

Table 2 shows that the percentage of the trips produced by the residents with destination into the urban area is relevant for both Cosenza and Rende (about 90% of the total trips).

Table 2. Daily trips for work and study purposes

	Internal trips	Trips with destination in Cosenza	Trips with destination in Rende	External trips	Total
Cosenza	22,157	-	4,138	3,441	29,736
Rende	11,462	4,535	-	1,738	17,735
Total	33,619	4,535	4,138	5,179	47,471

However, it is necessary to point out that census data refer to the trips made for work and study purposes only, but a relevant part of the daily trips is made for other purposes. As an example, by the same survey realized in the occasion of the urban traffic plan drafting of Cosenza it emerges that out of 5,075 home-based trips realized by a sample of residents in Cosenza, 38% are trips made for work and study purposes, but 62% area trips realized for other purposes. Therefore, we can retain that the commuter trips registered by the census represent only 38% of the total trips made in a day. By taking into account the complementary percentage (62%), a realistic value of the daily home-based trips amount to 124,924. This value could be further increased in order to take into account the non home-based amount of trips

4. Model

4.1. Structural Equation Modelling methodology

SEM is a relatively new method whose use is now rapidly expanding as user friendly software, like AMOS (Arbuckle and Wothke, 1995), become available. SEM is a specific type of regression analysis and explains relationships between independent (exogenous) and dependent (endogenous) variables. It is composed of up to three sets of simultaneous equations, estimated at the same time: (*i*) a measurement model for the endogenous variables, (*ii*) a measurement model for the exogenous variables, and (*iii*) a structural model. This full model is known as "SEM with latent variables". Latent variables are constructs which cannot be directly observed, but they must be defined in terms of underlying variables, called indicators, which are observed. Each latent variable is defined by a measurement model, whereas the structural model represents the relationships between exogenous and endogenous variables.

The basic equation of the structural model is the following (Bollen, 1989):

$$\eta = B\eta + \Gamma\xi + \zeta \tag{1}$$

in which η (eta) is an (*m x 1*) vector of the latent endogenous variables, ξ (xi) is an (*n x 1*) vector of the latent exogenous variables, and ζ (zeta) is an (*m x 1*) vector of random variables. The elements of the Β (beta) and Γ (gamma) matrices are the structural coefficients of the model; the Β matrix is an (*m x m*) coefficient matrix for the latent endogenous variables; the Γ matrix is an (*m x n*) coefficient matrix for the latent exogenous variables.

The basic equation of the measurement model (2) is for the exogenous variables and equation (3) is for the endogenous variables:

$$x = \Lambda_x \xi + \delta \tag{2}$$

$$y = \Lambda_y \eta + \varepsilon \tag{3}$$

in which *x* and δ (delta) are column *q*-vectors related to the observed exogenous variables and errors, respectively; Λ_x (lambda) is a (*q x n*) structural coefficient matrix for the effects of the latent exogenous variables on the observed variables; *y* and ε (epsilon) are column p-vectors related to the observed endogenous variables and errors, respectively; Λ_y is a (*p x m*) structural coefficient matrix for the effects of the latent endogenous variables on the observed ones.

SEM makes a distinction between direct, indirect and total effects. This aspect is very useful in order to obtain better insights into the complex nature of travel behaviour. Direct effects are the links that go directly from one variable to another variable, which is the target of the effect. Indirect effects occur between two variables that are mediated by one or more intervening variables. Total effects are the sum of direct and indirect effects, and represent the overall effect of an independent variable on a dependent variable.

The general SEM system is estimated using covariance analysis. This means that model parameters are determined such that the variances and covariances of the variable implied by the model system are as close as possible to the observed variances and covariances of the sample. The structural equation system is generally estimated by using the Maximum Likelihood method (ML), which maximizes the probability that the observed covariances are drawn from a population that has variance-covariances generated by the process implied by the model, assuming a multivariate normal distribution. ML estimation is fairly robust against violations of multivariate normality for sample sizes commonly encountered in transportation research (Golob, 2003).

4.2. General structure of the proposed model

In the proposed SEM, all the variables are referred to the census parcels. The model has four exogenous latent variables (“Socio-demographic characteristics”, “Economic characteristics”, “Land use” and “Accessibility”), and an endogenous latent variable (“Travel behaviour”). The measurement model relates the exogenous latent variables to the endogenous variable and two exogenous variables are related among them (figure 1).

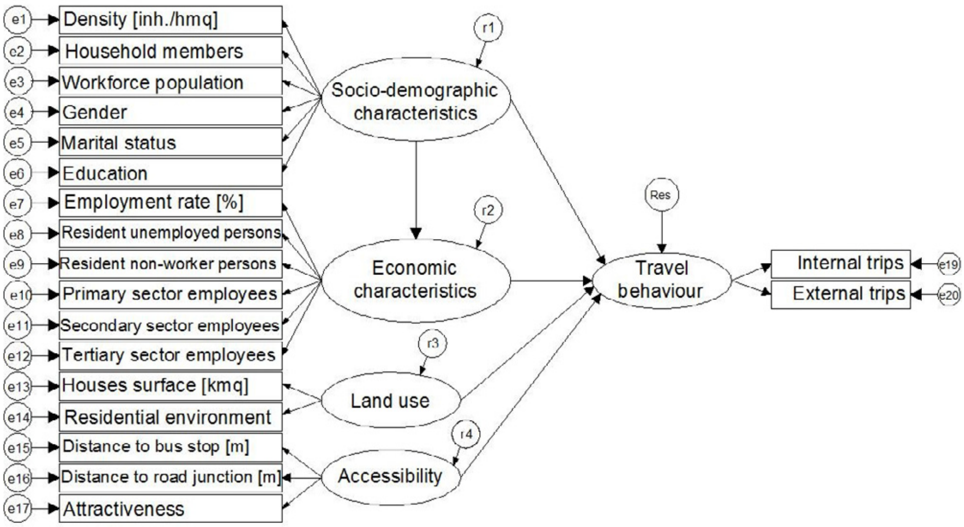

Figure 1. Structure of the model

The “Socio-demographic characteristics” latent exogenous variable is explained by six *x* observed variables as density (per square hectometre), household members, workforce, gender, marital status (single or married), and education. The “Economic characteristics” latent exogenous variable is explained by six observed variables, which are employment rate (percentage), resident unemployed persons, resident non-worker persons, and resident employees distinguished according to the economic sectors (primary, secondary and tertiary). The “Land use” latent exogenous variable is explained by two observed variables: houses surface (per square kilometre) and residential environment. Finally, “Accessibility” is explained by distance to bus stop (m), distance to road junction (m), and *i* attractiveness census parcel defined as

$$A_i = \sum_j^N P_j / d_{ij} \tag{4}$$

where P_j is the number of employees of the *j* destination; d_{ij} is the travel impedance between the *i* origin and *j* destination, which is the travel time by car between *i* and *j*.

The “Travel behaviour” latent endogenous variable is explained by two observed variables: the number of internal and external trips of the urban area.

Among the 19 observed variables, some are concerned population and employment status and defined on the basis of census data (ISTAT, 2001a; ISTAT, 2001b); others variables are GIS-based measures of land use and accessibility variables.

4.3. Model results

The model was calibrated by using the AMOS 4.0 package from SmallWaters Corporation (Arbuckle and

Wothke, 1995). To estimate the model, the constriction of a parameter to a value equal to 1 was necessary. Table 3 shows the model results. In the first and second column the model variables are shown; the third column shows the values of the coefficients of the model (named as "Regression Weights"); in the fourth and fifth column the value of the standard error (S.E.) of each coefficient and the probability level (P) that the estimated coefficient is significantly different from zero, respectively, are reported; finally, in the last column the values of the standardized coefficients of the model are shown, named as "St. Regression Weights".

Table 3. Model results

			Regression Weights	S.E.	P	St. Regression Weights
Latent endogenous variable		*Latent exogenous variable*				
Travel Behaviour (η_1)	<--	Socio-demographic characteristics (ξ_1)	1.000	-	-	0.019
Travel Behaviour (η_1)	<--	Economic characteristics (ξ_2)	14.641	1.799	0.000	0.964
Travel Behaviour (η_1)	<--	Land use (ξ_3)	142.359	31.559	0.000	0.231
Travel Behaviour (η_1)	<--	Accessibility (ξ_4)	-0.001	0.000	0.007	-0.025
Latent exogenous variable		*Latent exogenous variable*				
Economic characteristics (ξ_2)		Socio-demographic characteristics (ξ_1)	0.969	0.257	0.000	0.274
Observed exogenous variable		*Latent exogenous variable*				
Density [inh./hmq] (x_1)	<--	Socio-demographic characteristics (ξ_1)	9.192	4.314	0.033	0.072
Household members (x_2)	<--	Socio-demographic characteristics (ξ_1)	1.000	-	-	1.125
Workforce population (x_3)	<--	Socio-demographic characteristics (ξ_1)	0.008	0.004	0.060*	0.062
Gender (x_4)	<--	Socio-demographic characteristics (ξ_1)	0.087	0.022	0.000	0.195
Marital status (x_5)	<--	Socio-demographic characteristics (ξ_1)	-0.099	0.025	0.000	-0.199
Education (x_6)	<--	Socio-demographic characteristics (ξ_1)	-0.133	0.031	0.000	-0.263
Employment rate [%] (x_7)	<--	Economic characteristics (ξ_2)	1.000	-	-	0.274
Resident unemployed persons (x_8)	<--	Economic characteristics (ξ_2)	1.608	0.204	0.000	0.747
Resident non-worker persons (x_9)	<--	Economic characteristics (ξ_2)	13.698	1.691	0.000	0.930
Primary sector employees (x_{10})	<--	Economic characteristics (ξ_2)	0.194	0.027	0.000	0.500
Secondary sector employees (x_{11})	<--	Economic characteristics (ξ_2)	1.679	0.209	0.000	0.864
Tertiary sector employees (x_{12})	<--	Economic characteristics (ξ_2)	11.326	1.396	0.000	0.946
Houses surface [kmq] (x_{13})	<--	Land use (ξ_3)	0.056	0.014	0.000	0.780
Residential environment (x_{14})	<--	Land use (ξ_3)	1.000	-	-	0.201
Distance to bus stop [m] (x_{15})	<--	Accessibility (ξ_4)	-1.729	0.780	0.027	-1.241
Distance to road junction [m] (x_{16})	<--	Accessibility (ξ_4)	-1.134	0.360	0.002	-0.744
Attractiveness (x_{17})	<--	Accessibility (ξ_4)	1.000	-	-	0.077
Observed endogenous variable		*Latent endogenous variable*				
Internal trips (y_1)	<--	Travel Behaviour (η_1)	1.000	-	-	0.994
External trips (y_2)	<--	Travel Behaviour (η_1)	0.126	0.002	0.000	0.921

*not significant at a level of 5%

All parameters have a correct sign and assume a value statistically different from zero, at a good level of significance. Only one parameter is less statistically significant than others (level of significance of 6.0%). The minimum value of discrepancy function is 4,678, a value statistically significant according to the chi-squared test. Because the chi-square test of absolute model fit is sensitive to sample size and non-normality in the underlying distribution of the input variables, various descriptive fit statistics may be used to assess the overall fit a model to the data. The goodness of fit index (GFI) is 0.647, the adjusted goodness of fit index (AGFI) is 0.547, and the comparative fit index (CFI) is 0.667. These tests are quite satisfactory. The root mean square error of approximation (RMSEA) has a value of 0.191 and its lower and upper confidence interval boundaries are 0.187 and 0.196, respectively; these indexes have low values and therefore are quite good.

The household members observed variable has a major impact on the “Socio-demographic characteristics” variable. Similarly, tertiary sector employees indicator has a major impact on “Economic characteristics” variable, even if the weight of resident non-worker persons is considerable, and the observed variable named houses surface has greatest impact on “Land use” variable. Finally, distance to bus stop indicator has a major impact on “Accessibility” variable. The negative sign of this observed exogenous variable indicates that “Accessibility” decreases when the distance to the nearest bus stop increases. The “Travel behaviour” endogenous latent variable is mostly explained by indicator of the internal trips, even if the weight of external trips is considerable. The latent exogenous variable with the highest positive effect on “Travel behaviour” is “Economic characteristics”. Even “Land use” variable has an important weight, whereas “Socio-demographic characteristics” variable has a not very considerable regression weight. The case of the “Accessibility” variable is different because this variable has a negative effect on “Travel behaviour”.

It is important to analyse even the indirect effects due to interrelationships among the constructs. In fact, indirect effects may be quite strong and different from direct effects. Moreover, indirect effects may have the opposite sign of their direct effects, leading to different conclusions. Therefore, total effects must be interpreted instead of direct effects only.

Table 4. Standardized total effects on “Travel behaviour”

	Direct effects	Indirect effects	Total effects
Socio-demographic characteristics	0.019	0.264	0.283
Economic characteristics	0.964	-	0.964
Land use	0.231	-	0.231
Accessibility	-0.025	-	-0.025

Table 4 shows that, in terms of total effect, “Economic characteristics” remains the latent exogenous variable which influences mainly “Travel behaviour”, but the weight of “Socio-economic characteristics” is increased.

5. Conclusions

The aim of this research was to explain the relative influence of spatial variables of land use, socio-demographic and economic variables on travel behaviour. In this regard, a structural equation model was proposed. Using this model, latent (unobserved) variables may be defined from observed variables or indicators and the relationships between latent exogenous (independent) and endogenous (dependent) variables can be explained. In this research, the proposed model has four exogenous latent variables (“Socio-demographic characteristics”, “Economic characteristics”, “Land use”, and “Accessibility”), and an endogenous latent variable (“Travel behaviour”). Some observed variables are defined on the basis of census data and others are GIS-based measures of land use and accessibility. The preliminary results obtained from the calibration of the model suggest many observations. Firstly, the model allowed the significant of the relationship between observed and latent variables to be determined. Moreover, direct, indirect and total effects were distinguished and the total effects were considered as sensible for the analysis. These effects showed that “Economic characteristics” has a major influence on “Travel behavior”, whereas the weight of the others variables are lower. Moreover, for each latent exogenous and endogenous variable the observed variable with the major influence was defined.

Future development of the research can provide for the introduction of other kinds of data regarding land use and planning in the GIS, and of some data regarding the real estate market. In addition, the analysis was conducted on the basis of the census parcels. Interesting results could be obtained by using disaggregate units of analysis (e.g. individuals or households data) appropriately sought through *ad hoc* designed surveys.

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